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NEW TRENDS IN TECHNOLOGY AND THEIR APPLICATIONS: HYDROGRAPHY

New trends in hydrography

Submitted by the Secretariat**

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Broadly, this paper aims to highlight the significant developments in hydrography which have occurred in the last five years or so and relate them to their application in the Asian and Pacific Regions. The author has consulted many journals and conference proceedings in order to distil the contents of this paper. Due to length restrictions it is not possible to acknowledge the many sources: it must suffice to acknowledge all those colleagues who have contributed indirectly. The term "hydrography" is taken throughout this paper in its widest possible sense to include, but not be restricted to, survey data collection, chart production, navigation and data management. Occasionally a particular product is mentioned as an example of its class: this is not to be construed as endorsement of that particular product.

DATA COLLECTION AND POSITIONING

Differential GPS

The potential of the satellite based Global Positioning System (GPS) is well known. Raw accuracies improve as the full configuration is established. The additional accuracies required for hydrography can readily be achieved with the addition of a differential infrastructure (hence: Differential GPS [DGPS]) broadcasting Earth-based corrections to the field-based user. Particular attention to linkages must be given where near-shore or in-shore topography masks signals and work needs to be done on tempering user enthusiasm for GPS with its constraints and limitations. Systems such as SkyFix (Racal) provide a near world-wide datalink by combining GPS with INMARSAT communication satellites.

The continuing, necessary use of paper charts for navigation which are based on various national and local datums remains problematic as GPS use spreads among the marine community. GPS, of course, is not the sole precise positioning system and thus, like most electronic devices, GPS receivers continue to become cheaper and affordable in the market place. The hydrographic surveyor and the electronic chart user will continue to look to independent DGPS capability for their precise positioning. Racal reports better than plus or minus 7.5 metre accuracies up to 2,600 kms for most applications. One Australian hydrographic survey company, using its own locally established DGPS, reports accuracies to 4 metres over 600 kms. With the "black box" nature of GPS navigation, field surveyors strive to ensure DGPS integrity through the use of monitor stations or by using it in combination with other navigation aids.

Within the region GPS, particularly DGPS, offers potential to improve both surveying and chart use accuracy. It needs to be kept in mind that continuing access to GPS depends on the US military though should access ever be denied it may well be the case that a commercial venture would establish a replacement.

One potential competitor is a Russian system based on a different satellite configuration (GLONASS) though the longer term viability of GLONASS remains problematic.

Ship trends

Current economic pressures continue to influence a trend away from the larger, crew and fuel intensive ships for more economically viable vessels. Nations seem to be adopting vessels on a mixture of rationales rather than any inherently strong advantage of any particular type. Some have acquired SWATH (Small Water Area Twin Hull) vessels which offer stability, very high transit speeds and fast surveying speeds (e.g. 17 knots). The Royal Australian Navy (RAN) Hydrographic Service looks towards smaller crewed vessels and also runs large, shallow draught catamarans. It has recently acquired custom-built Survey Motor Boats of 10.7 metre length. Normally crewed with four personnel they can be operated with two. No longer is sophisticated field equipment the sole domain of the large survey vessel. The Australian SMBs are fitted for DGPS, microwave and HF fixing systems, an all-weather JRC radar and a coursemaster autopilot which is interfaced to the RAN data logging and processing system, HYDLAPS. Additional fittings include an electronic log and a flux-gate compass. They are equipped to operate side-scan sonar. Six vessels cost just under $2 million Australian and one has been designed for Antarctic operations at a cost of $0.4 million Australian.

Many nations possessing ageing hydrographic vessels will look to the modern design trends for replacements. Such trends are of obvious interest to the region though it is probable that regionally developed capabilities could be used more effectively on a co-operative basis.

Swath Sounding Systems

Hydrographic data gathering can be likened to the blind person, tapping herself along, with other senses attuned to a higher sense of alertness than those lazier mortals who can rely on their sight. So the lead line (earliest remote sensing?) gave way to echo sounding. Efficiencies come from multibeam systems as they offer swath capability for both inshore and offshore surveys. A modern fanbeam system, such as BOTTOMCHART, offers accuracy from smaller vessels in shallow to medium depth applications. Canada has reported particularly good results from multibeam echo sounders on a SWATH vessel to 800 metres depth. The use of such systems assume that adequate large volume data acquisition and resolution systems are available.

As multibeam echo sounding systems increasingly become used in hydrographic applications, they complement the usual bathymetric capability with imaging from sonar techniques. Data rates are high and generally efficient. Very generally, fansweep systems offer accuracy with compactness, mobility and lower cost when compared with multiple mounted transducer systems. The Atlas HydrosweepDS system incorporates cross-fan calibration techniques (at right angles to the survey sweep) for more efficient minimisation of refraction

errors along the sound path. Clever algorithms overcome wave refraction distortions in the beam fan.

Such systems offer the economic surveying of large sweeps of the ocean and have obvious application with the region, particularly for the island nations. The limits of their use seem more dictated by ship availability than costs though, with greater awareness of legal implications, such systems may well become mandatory as hydrographic offices seek to fulfil their "duty of care".

Laser Airborne Hydrography

In the quest for efficient coverage of vast areas of the ocean a number of laser depth sounding systems have been developed for helicopter and fixed wing airborne platforms. Canada and Sweden have developed systems for use in helicopters and the Royal Australian Navy Hydrographic Service has been operating (for over a year) the Australian designed and built Laser Airborne Depth Sounder (LADS).

LADS is a self-contained hydrographic data collection, processing and analysis facility capable of operating in relatively remote or isolated localities providing complete field processing, analysis and integrated logistic support in the field.

The operation of the system is now proven and it is capable of fast, flexible, survey deployment, rapid data collection, rapid data processing (approaching a 1:1 ratio in terms of time for data collection), 100% coverage of shallow, dangerous waters, such as the Australian Great Barrier Reef where ship borne survey is dangerous, difficult and sometimes impossible. LADS has the ability to collect data in survey sorties of up to seven hours duration which represents the potential to collect over three million soundings covering 120 square kms in one flight, making LADS an extremely cost effective operation in these areas.

The LADS system consists of two functional groups of equipment. Firstly, the airborne system, comprising the Laser Depth Sounding Subsystem (LDSS) and the Airborne Data Acquisition Subsystem (ADAS) mounted in a Fokker F27-500 aircraft and secondly, a ground system comprising the Ground Analysis Subsystem and the ground Support Equipment which include a mobile data processing facility, a mobile maintenance facility and a mobile power unit to support the aircraft.

LADS has been designed to be independent of aircraft functions and in certain areas, functions have been duplicated to avoid interaction between the two systems. The airborne equipment is therefore considered as baggage by aviation authorities and it can be fully removed in four hours. LADS is operated by the Royal Australian Navy and is maintained for operation by a private firm, BHP Engineering Pty. Ltd.

The laser has proven very reliable. It has a pulse rate of 168 pulses per second and has been known to penetrate to depths of 70 metres in trials. The full scale deflection of the recording equipment has recently been modified to accept depths to 60 metres rather than 50 metres. Despite the apparent costs of such systems, LADS has already discovered Penny Shoal, a previously uncharted granite shoal, some 50m x 20m rising to 11.9m in an area generally 20m deep.

The shoal is of navigational significance, lying as it does within a nautical mile of a busy harbour approach regularly used by bulk carriers drawing up to 14m. LADS' current operation off Rockhampton, Central Queensland, has reported at least two potential channels through the Great Barrier Reef of great potential economic benefit to Australia's maritime trade. The existence and depth of Penny Shoal were subsequently confirmed by a surface hydrographic vessel

The costs of such systems could be defrayed if an Asian and Pacific capability could be developed. LADS is ideally suited to surveying waters of archipelagic countries such as Indonesia and the Philippines and countries such as Thailand and Malaysia to assist in coastal navigation, resource evaluation and planning and environmental management. Potential exists for collaboration of the countries bordering the South China Sea to commission a large scale, rapid survey of the area to improve or establish regional charting which would potentially reduce coastal navigation times, reduce the risk of environmental accidents and provide data for marine resource evaluation and planning. It would be unreasonable to expect these countries to fund such surveying totally and ways could be explored of levying international shipping for setting up such a regional capability. However, it is one thing for "only" ships to be at risk but with increasingly dangerous cargoes it is the adjacent nation that is also at heavy risk. Pacific island countries could benefit from the range and capability to define their shallow water approaches and improve their charting at a large scale. A joint proposal between Australia and Indonesia now exists under which the Indonesian Agency for the Assessment and Application of Technology (BPPT) will assess the LADS technology and its application to Indonesia's surveying needs, particularly in the area of resource evaluation and planning

TECHNOLOGICAL IMPERATIVES

Geographic Information Systems (GIS)

As the linkages between computer graphics capabilities and affordable data bases grow there is an increasing use of computer-based Geographic Information Systems for resource management, particularly in the area of coastal zone management. Such systems are highly dependent on the availability of digital data to realise their true potential. Their introduction within the region varies greatly (compare Singapore to other smaller nations) and has to be accompanied with a capability to acquire digital data from both field survey and by the digitisation of extant data sets.

Low Cost Digital Chart Production Systems

Many nations incorporate some degree of digital assistance in their marine chart production. This ranges from the simple use of the computational power of computers to full chart production (Australia, New Zealand, Singapore are examples in the region). Digital chart production does not guarantee ECDIS compliance: such compliance requires adherence to a complete digital philosophy (i.e. including digital source data). However, a number of companies

offer low entry cost micro systems (PC or work-station based) for chart production which offer a capability to most Asian and Pacific countries. Systems support for the region could be costly, however the few products available are known to be robust within their defined capabilities. These systems at least offer an educational and training basis for the region to embark on digital production and, eventually, the production of authorised ECDIS data bases. Malaysia and Singapore already utilise modern digital charting systems.

ECDIS (Electronic Chart Display and Information System)

The last decade or so has seen the development of ECDIS systems and the International Hydrographic Organisation (IHO) has co-ordinated this development through a number of its committees. Eventual acceptance for ECDIS of "functional equivalence" (to the paper chart for carriage purposes) by the International Maritime Organisation (IMO) seems assured, possibly as early as 1995. IMO is actively encouraging member states to create data now, emphasising environmental protection. ECDIS, as the name implies, incorporates an electronic chart image on a screen supported by a data base, together with a real time positioning system such as GPS to provide the mariner with a fully real time navigation system. This ambitious concept has taken many centuries of human development time and it is becoming clearer that the remaining areas of difficulty arise from the supply of authorised digital electronic chart data (the "base").

The IHO has sponsored data base and digital data exchange standards (S-57) and their use. Many nations, including Australia, have devoted considerable time to testing and applying these standards to good effect. Australia, for one, is taking steps towards issuing S-57 compliant data bases for its area of charting responsibility although complete coverage will take some years to develop.

During development of the ECDIS concept systems manufacturers began to offer lower cost graphics and data base systems which generally overcame the technical requirements of ECDIS. An IHO sub-committee has defined, as part of S-57, ECDIS display standards and graphics conventions for all operational conditions. Lack of authorised data bases forced manufacturers to digitise their interim data bases and so it is possible to find many suppliers of electronic chart systems claiming various degrees of IHO/IMO compliance, though few, if any, have adequately overcome the potential issues of liability arising out of electronic chart updating.

Hydrographic offices have always provided "authorised products": a contemporary problem for them is the provision of "authorised data bases". The need for authorised digital data bases which meet ECDIS requirements will place pressure on Asia - Pacific nations to develop compliant regional data bases which also meet the needs of international mariners, recreational mariners and fishermen. At times these requirements will conflict with national priorities. It will rarely be sufficient to take data directly from the existing paper chart; much reworking of the source hydrographic data will no doubt be necessary as charts are redefined for an Earth centred datum to meet the needs of the GPS users and ECDIS users alike.

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Despite the difficulties and resource intensity involved, as the full potential of the "Information" component of ECDIS is realised the synergy from ECDIS will be realised. An example of such potential synergy lies in the area of Vessel Traffic Management, an issue of current interest within the ASEAN nations. ECDIS, as an enabling technology brings with it the potential to better manage vessel deployment for economic, as well as national security reasons. At least one system available in the market can be used as a survey data logger, an electronic chart system and a vessel traffic system, all from the same platform (Atlas), indicating how standards and applications are merging.

It seems likely that the mature ECDIS will place demands on the countries of the region to regionalise their data base provisions for ECDIS. Regional Hydrographic Office activities would seem to offer the most appropriate basis upon which to build chart updating services as ECDIS becomes more widespread in its use. Many obstacles will need to be overcome for this to come about. These obstacles include such questions as data ownership, copyright, liability, revenue apportionment, educational arrangements and standards, and the sources of long term funding of such a regional capability.

It would seem appropriate for the UN to sponsor a Regional Conference to debate some of these issues in order that all viewpoints can be expressed and heard. Without such a forum the region might be forced to accept principles affecting their hydrography decided in other regions of the world.

LEGAL IMPERATIVES

Sovereignty of Data Ownership

The Royal Australian Navy Hydrographic Service is of the view that it is necessary for purposes of maritime safety and its continued operation that hydrographic data, exploited in other products, should clearly remain within the ownership and control of the Hydrographic Service. While the Royal Australian Navy Hydrographic Service will, as part of a commercial operations policy, allow other approved bodies to exploit the data, it will retain ownership and control of the original data. The issue of data ownership needs to be widely discussed within the Asian and Pacific Regions.

Copyright

The protection afforded to hydrographic works by Australia's Copyright Act and, internationally, by virtue of Australia's membership of the Berne Convention and the Universal Copyright Convention, are seen as keystones in the Royal Australian Navy Hydrographic Service's policy for protection of the integrity of its hydrographic products, the commercial exploitation of those products and the restriction of their misuse. The Hydrographic Service pursues an active program of preventing infringement of its products by calling upon the Australian Government Solicitor to intervene on its behalf whenever necessary.

The Royal Australian Navy Hydrographic Service does not seek to restrict use of its products when that use is legitimate in terms of fair commercial reward and in accord with safe maritime practice.

The advent of the electronic chart and the electronic data base raises particular issues as the copyright protection of data bases, computer displays and screen displays remains uncertain both domestically and internationally. The Hydrographic Service is, with the assistance of the Australian Government Solicitor, attempting to have these issues examined at the international level with the aim of achieving a legislative framework that affords appropriate protection.

Given the regional nature of such issues the copyright of hydrographic data and its use need discussion in regional forums.

Liability

The Royal Australian Navy Hydrographic Service has been concerned for some time about its potential liability arising from the collation of hydrographic data and the publication of maritime charts from this data. Similar concerns are known to exist in the hydrographic offices of the Asia - Pacific Region.

Hydrographic Services are concerned that they may be held liable for negligence where losses are sustained as a result of errors contained in navigational charts. This concern is amplified if the Hydrographic Service is viewed as coming under a higher duty of care because in providing hydrographic data it is performing a public good. The Royal Australian Navy Hydrographic Service is of the view that ECDIS creates a stronger relationship of reliance by the mariner on hydrographic information and as a result the prospect of liability being incurred is increased. The situation is complicated when the data bases potentially contain data from a number of regional nations.

The prospect of strict liability being imposed for defective maritime charts, without the need to prove any negligence, under recent Australian and international products liability legislation is also viewed with concern by the Royal Australian Navy Hydrographic Service. The Service's concerns are not assisted by the current uncertainty in Australia as to whether the ECDIS data base would come within the scope of the legislation. The Service is particularly concerned that its operations recognise its potential liability by the implementation of appropriate quality control systems.

Such issues, once again, need to be discussed by senior personnel from the hydrographic offices of the region.

Standards

The internationality of the mariner's requirements and the boundary crossing nature of ECDIS forces the issue on International Standards. Considerable research and effort has gone into the development of IHO sponsored Standards S-52 (ECDIS) and S-57 (Data Exchange Standards). At higher levels compatibility has been sought with the SDTS (Spatial Data Transfer Standard) as well as a number of military Standards. The work on agreed Standards is largely completed. The issue for Asian and Pacific countries is how to achieve their implementation. IHO member states will have to seek adequate national

infrastructures and regional structures to co-ordinate charting data as well as the all important chart updating procedures that follow.

Data Management

The advent of improved means of collecting digital data such as the various swath, multi-beam and laser systems, and the requirements of GIS and ECDIS for digital data is leading to an explosion in digital data which needs management. Some regional hydrographic offices such as Australia are advanced in their thinking and implementation of digital data management systems and techniques while others have no, or only little experience. Training will be the issue for the region as the technology costs become lower and technology implementation imperative.

The main technological thrusts impacting upon hydrography are leading to an embarrassment of riches in the form of megabytes of data. The forthcoming era of hydrography will have to address the processing of these large volumes data sets concentrating on statistical quality assurance, as opposed to individual human analysis techniques for merging such sets, and managing the consequent high volume data sets that result.

OTHER IMPERATIVES

Sovereignty and the Potential of ECDIS

ECDIS will prove invaluable in the fields of marine resource management and the portrayal of UNCLOS defined boundaries.

Part V, Article 56 defines the coastal states rights, jurisdiction and duties with respect to the Exclusive Economic Zone. Briefly this Article, together with Articles 61 and 62 establish the sovereign rights available for the exploitation of living and non living resources of the seabed, subsoil and superjacent waters, but it also lays a specific duty upon the coastal state to conserve and manage stocks sensibly. In the case of living resources this may mean restrictions on exploitation, by genus, age, size, season or geographical area. The database can carry the full details of the exploitation and management policies for display and/or manipulation, including the degree to which stocks may be shared with other states to facilitate optimum and sustainable harvesting.

Part VI, Article 77, defines the sovereign rights of a coastal state in relation to its continental shelf. A data base for resource exploitation and management could be built up for the continental shelf in much the same way as it is proposed for the Exclusive Economic Zone.

Under Articles 133 to 191 inclusive of Part XI of UNCLOS 82, great value in defining lease areas and their relevant resource identities and potentials could come from the employment of ECDIS, should the exploration and exploitation of "The Area" become a reality. "The Area" is that part of the sea-bed, ocean floor and subsoil outside any national jurisdiction. Management of The Area will be regulated by the Sea-Bed Authority, whilst exploration and exploitation will be undertaken by either the operating arm of the Sea-Bed Authority, known as The

Enterprise, or commercial ventures under lease agreements obtained from the Sea-Bed Authority.

The implication here for the region is that there are more reasons other than safe navigation for implementing ECDIS.

Total Quality Management

The currently vogue management philosophy of Total Quality Management (TQM), where implemented, has profound implications on the standard, accepted processes of hydrographic surveying. Traditionally, the hydrographic surveyor goes to work in the field and the quality processes emphasise the detection of errors or deviations from specifications after the survey results are completed. The hydrographic surveyor, as a professional, adheres to agreed specifications and internationally accepted practices to achieve the desired result. TQM emphasises that the particular process strives towards continual marginal improvement with a view to eliminating potential errors or deviations to achieve desired results. Thus the hydrographic surveyor and particularly, the hydrographic contractor, will have to demonstrate objectively that he/she is meeting the desired specification during the surveying process. The potential costs savings to those nations which rely heavily on hydrographic survey contracting potentially can realise great resource and time savings if TQM is adopted as a philosophy as frequently, survey reworking is the accepted method of quality assurance. However and like all 'new' approaches which challenge reliance on the professions the author suspects that TQM will find greater acceptance where the survey task is great, and ongoing. The contracting nation will have to construct its own cost curves before settling on quality assurance procedures. If a TQM approach is adopted then the scarce surveying resource should spread further.

Regional nations could be well served by exposure to the methodologies of TQM in the fields of hydrographic surveying and charting. TQM, of course, has relevance for existing practices at whatever level.

CONCLUSIONS

A review of this paper reveals a number of trends: technological, managerial and organisational, that bear on the region's hydrography. They all have a common theme; that is, they are all regionalising in their impacts. Exposure to these developing trends, both at the higher management level and the technician level, could facilitate the regionalisation of hydrographic services in Asia and the Pacific. Sponsorship by the UN of a hydrographic workshop for Senior Administrators and Senior Professional personnel from Hydrographic Agencies within the Region would be a pragmatic first step towards achieving modern hydrography for the entire Region. The agenda for such a workshop could be based on the headings of this paper.

Although much of the current hydrographic technology is probably beyond the reaches of many Asia and Pacific nations it seems sensible to suggest that a regional capability could be deployed where necessary to improve the poor charting which remains in large areas of the Region.